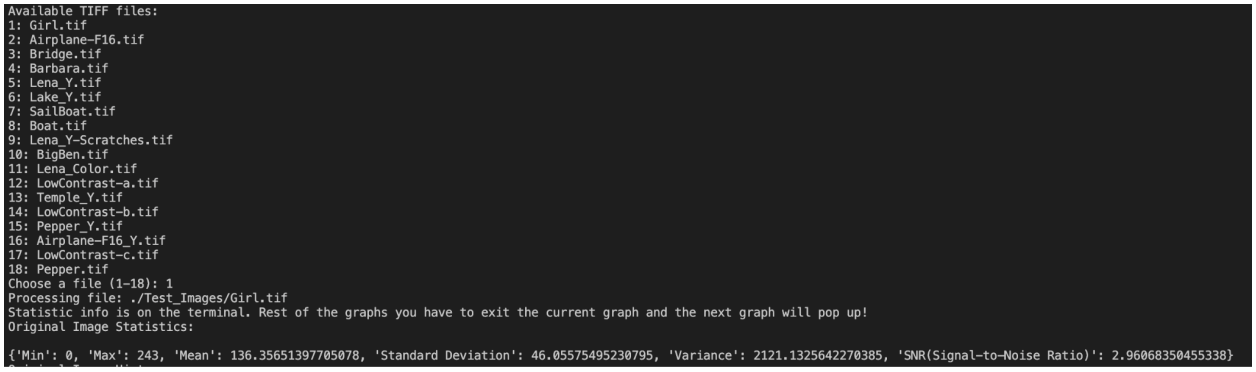
Advanced Image Processing

In this report, I will present a detailed analysis of a grayscale image by evaluating its statistical characteristics, performing contrast enhancements using histogram equalization and linear contrast correction, and evaluating the statistical changes after enhancement. This assignment allows me to explore key image processing techniques and apply them to improve image quality, specifically focusing on grayscale images with intensity values ranging between 0 and 255. In this assignment, the python main file takes all test images (tiff) and asks the user which image to utilize.

Q1.1)

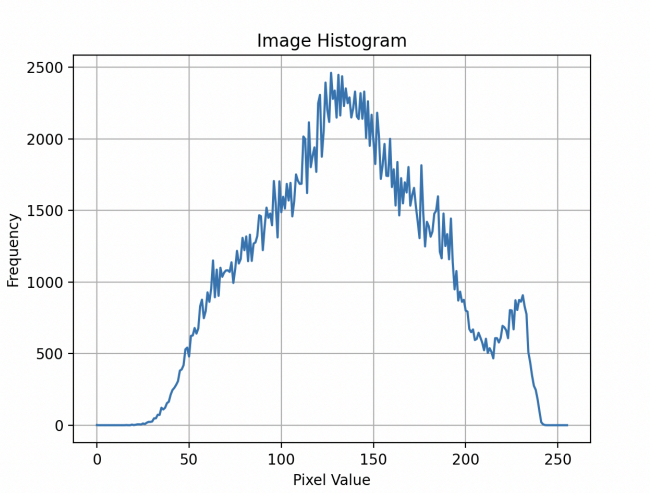
For the initial image analysis, a function was developed to evaluate the following statistical metrics for the grayscale image. In this sense we used min, max, mean, standard deviation, variance and SNR.

Minimum intensity: The lowest pixel intensity value in the image.
Maximum intensity: The highest pixel intensity value in the image.
Mean intensity: The average pixel intensity value across all pixels.
Standard Deviation: Measures the spread of pixel intensity values around the mean.
Variance: The square of the standard deviation, representing intensity distribution.
SNR (Signal-to-Noise Ratio): The ratio of the mean intensity to the standard deviation, which quantifies image quality.



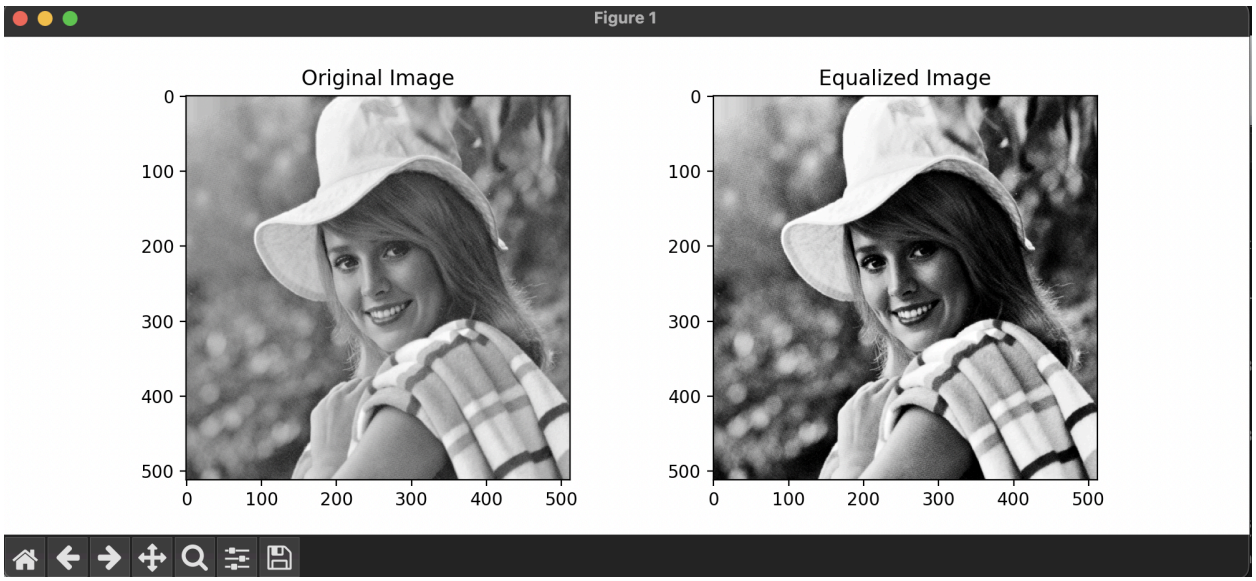
Q1.2)

A histogram function was created to evaluate and plot the distribution of pixel intensities in a grayscale image. The histogram provides insight into the range of pixel intensities and the frequency of occurrence of each intensity value. A plot was generated to visualize the intensity distribution before and after enhancement.



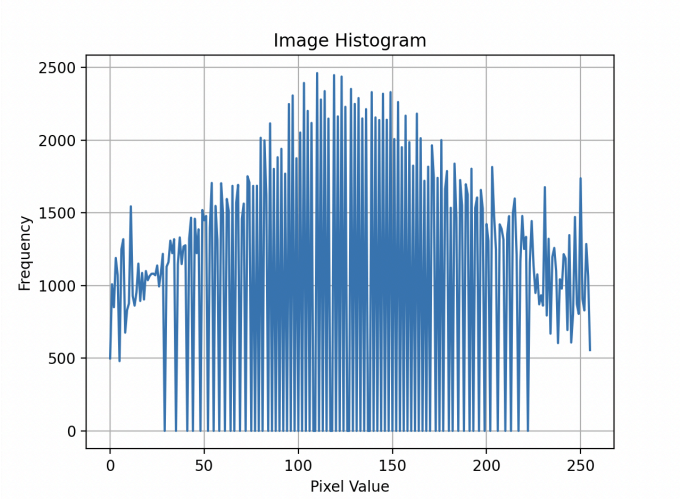
Q1.3)

To improve the contrast of the grayscale images, histogram equalization was implemented. Histogram equalization redistributes the pixel intensity values so that they are spread more evenly across the entire intensity range, improving contrast in areas with poor visibility. The output is a new image with enhanced contrast, which was displayed alongside the original image for comparison.



Q1.4)

Linear contrast correction adjusts the pixel intensity values to achieve a desired mean and standard deviation. This technique was applied by modifying the intensity values linearly, based on the original mean and standard deviation of the image. The function designed for this purpose accepts the grayscale image, a target mean, and a target standard deviation, and it outputs an enhanced image that matches the desired characteristics.



Question 2)

Q2.A)

Min	0
Max	243
Mean	136.35651397705078
Standard Deviation	46.05575495230795
Variance	2121.1325642270385
SNR(Signal-to-Noise Ratio)	2.96068350455338

Q2.B)

Histogram of Original Image

The histogram of the original image revealed a skewed distribution with most pixel intensities concentrated in the mid-to-low range, leading to poor contrast. (histogram on the top)

Q2.C) Contrast Enhancement via Histogram Equalization

After applying histogram equalization, the image showed significant improvement in contrast, particularly in previously underexposed areas. The intensity values were redistributed, enhancing the visibility of finer details.

Min	0
Max	255
Mean	128.2613754272461
Standard Deviation	73.59737980673492
Variance	5416.574314416794
SNR (Signal-to-Noise Ratio)	1.7427437738144702

P.S. The histogram after equalization showed a more uniform distribution of pixel intensities. (Histogram is on the top)

Q2.C) Contrast Enhancement via Linear Contrast Correction
The image was further enhanced using linear contrast correction with a target mean of 127 and a target standard deviation of 63.

Min	0
Max	255
Mean	127.41416931152344
Standard Deviation	63.52787802014043
Variance	4035.7912857418414
SNR(Signal-to-Noise Ratio)	2.0056418265872025

The experiment demonstrated that both histogram equalization and linear contrast correction are effective methods for improving the contrast of grayscale images. Histogram equalization resulted in more visually striking contrast enhancement compared to linear contrast, however it can lead to over enhancement and noise amplification. While linear contrast correction provides more control over the enhancement by targeting specific mean and standard deviation values, making it suitable for applications where precise control of image. The SNR was lower after histogram equalization due to the amplification of noise, while linear contrast correction maintained a relatively higher SNR.

Screenshot Samples: